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CALIBRATION OF THE SECONDARY EMISSION CHAMBERS CE010 AND A300

I. Introduction

Since mid October 1975 a series of measurements have been made to intercalibrate beam intensity measuring devices and methods e.g. current transformers[1], secondary emission chambers[2,3] and foil irradiation techniques[4] in both fast ejected and slow ejected beams. A complete report of these measurements is in preparation. In this technical note, we report on the intercalibration of SEC CE010 and SEC A300 which was felt necessary after these two SEC's were interchanged during the January 1976 shutdown of the AGS.

II. Calibration of the SEC CE010, January 16, 1976

Three sandwiches of thin polyethylene and aluminum foils were prepared and installed inside the instrument box C12 in vacuum immediately downstream of the SEC CE010. Each sandwich consisted of 3 polyethylene and 3 aluminum foils. The fluxes of the 28 GeV protons were determined using the following two nuclear reactions:[5]

$$^{12}_{6}\mathrm{C}\ (\mathrm{p,pn})\ ^{11}_{6}\mathrm{C}$$

$$\left[\sigma = 2.5 \times 10^{-26} \text{ barns} \quad \text{and} \quad \lambda = \tau^{-1}\ (\ell n\ 2)^{-1} = 3.3977 \times 10^{-2} \text{ min}^{-1}\right]$$

and

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$${}^{27}_{13}A\ell\ (p,3pn)\ {}^{24}_{11}Na$$

$$\left[\sigma = 8 \times 10^{-27} \text{ barns} \qquad \lambda = 7.7016 \times 10^{-4} \text{ min}^{-1}\right] .$$

The activity of the foils was measured in the "W3" scintillation counter of the Chemistry Department which has an efficiency of 0.636 for ${}^{11}_{6}C$ radiation and 0.513 for ${}^{24}_{11}Na$ radiation. The SEC's were calibrated previously against the current transformer in the fast ejected proton beam and were set such that 1 SEC count = 10^9 protons ± 5%.

During irradiation the SEC registered:

SEC CE010 = 12219 counts

which corresponds to a proton flux of

UT799 ≃ 1.222×10^{13} protons.

Proton Fluxes Derived From the Irradiated Foils

A) CH_2 (polyethylene) foils:

Sandwich A	foil #1	$I_p = 1.307 \times 10^{13}$ protons
(normal to the beam)	foil #2	$I_p = 1.290 \times 10^{13}$
	foil #3	$I_p = 1.290 \times 10^{13}$
		$<I_p> = 1.295 \times 10^{13}$
Sandwich B	foil #1	$I_p = 1.277 \times 10^{13}$
(45° to the beam,	foil #2	$I_p = 1.203 \times 10^{13}$
corr. for angle)	foil #3	$I_p = 1.308 \times 10^{13}$
		$<I_p> = 1.262 \times 10^{13}$
Sandwich C	foil #1	$I_p = 1.438 \times 10^{13}$
(normal to the beam)	foil #2	$I_p = 1.293 \times 10^{13}$
	foil #3	$I_p = 1.314 \times 10^{13}$
		$<I_p> = 1.340 \times 10^{13}$
All CH_2 foil mean		$<<I_p>> = 1.300 \times 10^{13}$

and the ratio is: $\dfrac{\text{SEC CE010}}{<<I_p>>\ CH_2} = \dfrac{1.222}{1.300} = 0.94$.

B) Aluminum foils.

Sandwich A	foil #1	$I_p = 1.275 \times 10^{13}$	protons
(normal to the beam)	foil #2	$I_p = 1.276 \times 10^{13}$	
	foil #3	$I_p = 1.276 \times 10^{13}$	
		$\langle I_p \rangle = 1.276 \times 10^{13}$	
Sandwich B	foil #1	$I_p = 1.222 \times 10^{13}$	
(45° to the beam,	foil #2	$I_p = 1.233 \times 10^{13}$	
corr. for angle)	foil #3	$I_p = 1.233 \times 10^{13}$	
		$\langle I_p \rangle = 1.230 \times 10^{13}$	
Sandwich C			
(normal to the beam)	foil #1	$I_p = 1.237 \times 10^{13}$	
	foil #2	$I_p = 1.268 \times 10^{13}$	
	foil #3	$I_p = 1.255 \times 10^{13}$	
		$\langle I_p \rangle = 1.253 \times 10^{13}$	
All Aℓ foils mean		$\langle\langle I_p \rangle\rangle = 1.250 \times 10^{13}$	

All Aℓ foils mean

and the ratio is: $\dfrac{\text{SEC CE010}}{\langle\langle I_p \rangle\rangle\ A\ell} = \dfrac{1.222}{1.250} = .97$.

III. Calibration of the SEC in the "A Line" (A300)

Only one sandwich of 3 polyethylene foils and 3 aluminum foils were irradiated in the A line. The sandwich was placed several cm after the SEC in the A line.

During irradiation in SEC in "A line" registered:

$$\text{SEC A300} = 10025 \text{ counts} = 1.0025 \times 10^{13} \text{ protons.}$$

The W3 scintillation counter was used for measuring both the CH_2 and Aℓ foil activities. The CH_2 foil activities were measured by the authors (V. Agoritsas and J. Balsamo). The aluminum foil activities were measured by J. Burger. The results are:

A) Polyethylene foils	foil #1	$I_p = 1.016 \times 10^{13}$
	foil #2	$I_p = 1.001 \times 10^{13}$
	foil #3	$I_p = 1.023 \times 10^{13}$
		$\langle I_p \rangle = 1.013 \times 10^{13}$

and $\frac{\text{SEC A300}}{\langle I_p \rangle} = \frac{1.0025}{1.013} = .99$.

B) Aluminum foils

#1, 2, 3 $\langle I_p \rangle = 1.058 \times 10^{13}$ protons

$$\frac{\text{SEC A300}}{\langle I_p \rangle} = \frac{1.0025}{1.058} = .95 \quad .$$

Another sandwich of only three aluminum foils in the A line gave

$$\langle I_p \rangle = 5.239 \times 10^{13}$$

while the SEC A300 registered 50437 counts = 5.0437×10^{13} protons.

$$\frac{\text{SEC A300}}{\langle I_p \rangle} = \frac{5.0437 \times 10^{13}}{5.239 \times 10^{13}} = \underline{\underline{0.96}} \quad .$$

IV. Conclusion

The obtained results are within the relative expected discrepancies of the foil irradiation measurements. In our final report we shall discuss the observed discrepancies. Thus it must be concluded that to within the experimental variation, there is no difference in calibration between the calibration of the CE010 SEC and the A300 SEC, but the calibration may be as much as 5% low compared to foil measurements.

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